CLIVAR

FY 2001

> The following is excerpted from the FY2001 program guidance given by the U.S. CLIVAR Scientific Steering Committee to the U.S. CLIVAR agencies. It is provided here as background for NOAA's FY2001 CLIVAR's Program Announcement. For additional reference material, U.S. CLIVAR is drafting implementation plans for the Atlantic, Pacific and Pan American regions. These plans may be found on the U.S. CLIVAR website.

The U.S. CLIVAR program on climate variability is evolving along the following avenues of research outlined by the International CLIVAR science and implementation plans: improved predictability of ENSO; understanding other patterns of seasonal-to-interannual variability including their potential predictability; diagnosis of patterns of decadal variability; testing models of anthropogenic change through their ability to reproduce natural climate variability. Additional avenues are being developed.

U.S. CLIVAR seeks to observe, model and understand natural variability on seasonal to decadal time scales, to assess the predictability of such climate variability, and to detect and attribute anthropogenic influences on climate variability.

Current objectives are an improved understanding of the following phenomena:

- ENSO, particularly the decadal variability of its evolution and its teleconnections. The candidate mechanisms advanced to explain modulation of the ENSO cycle need to be tested and models for simulating the ENSO cycle and its interactions with the subtropics, with the Americas and with the Atlantic and Indian Oceans need to be improved.

- The North Atlantic (or Arctic) Oscillation (NAO/AO), especially its sensitivity to local and remote surface forcing, its interaction with the underlying ocean, possible links to the stratospheric polar vortex, and the causes of the apparent trend in the strength of the NAO over the past 30 years.

- The role of land processes in generating coupled ocean-land- atmosphere variability of the Pan American Monsoon and tropical Atlantic and eastern Pacific climate.

- Tropical Atlantic Variability (TAV), especially the local and remote processes responsible for the substantial observed sea surface temperature variability, the interaction of TAV with and influence on other modes of climate variability, an improved understanding of the sensitivity of TAV to anthropogenic forcing (e.g., potential desertification of Amazonia), and assessment of the potential predictability of TAV.

- The interaction of the Pan American Monsoon and TAV with extratropical climate variability (e.g. NAO or North American warm-season climate variability). This includes other sources of predictability of warm-season precipitation over the Americas on seasonal and longer time scales.

- The Pacific Decadal Oscillation (PDO), particularly its mechanism and predictability, the role of air-sea interaction in setting its time scale, its influences on continental climate and connection to ENSO.

Achieving these objectives will require (a) improved empirical studies of previous climate phenomena, (b) sustained and improved basin wide observations of the atmosphere, ocean and land, (c) synthesis of observations and numerical models through data assimilation, (d) in-depth analyses of the output of, and new runs with, coupled models, and (e) experiments to better quantify processes in climate models.

For FY2001, U.S. CLIVAR encourages proposals in the following broad areas.

Conduct empirical, modeling and diagnostic studies of coupled land- ocean-atmosphere phenomena in the Atlantic, Pan American and Pacific sectors with an emphasis on seasonal-to-interannual climate variability but including decadal time scales.

The U.S. CLIVAR program seeks to understand and improve predictive skill of seasonal-to-interannual climate variability over the Americas by carrying out coordinated research on seasonal-to-decadal climate variability in the Pacific, Pan American and Atlantic sectors. In addition to its value in improving climate prediction, CLIVAR research on the natural variability of the Pan American climate will be crucial to detecting and understanding human impacts on climate. For example, there is growing consensus that the tropics will be an area of great change due to anthropogenic effects on climate. All estimates of projected greenhouse gas emissions and aerosol loading for the 21st century indicate the largest changes will occur in the tropical belt. Emissions of sulfur are projected to be quite large for the Central and South American region. The implications of this for changes in local circulations (e.g. monsoon) are significant. Deforestation and other anthropogenic changes are expected to be large as well.

A focus on seasonal-to-interannual phenomena is suggested. Although empirical and diagnostic studies have described the seasonal shifts and variability of the heat sources and circulation over the tropical regions of Latin America and the mountainous regions of the Sierra Madre and the Andes, much remains uncertain. Inadequate (both in quality and coverage) observations and lack of available historical data have limited progress. Over much of Latin America, model-based climate reanalyses are unconstrained and unvalidated by observed data. The structure of the low-level winds that supply moisture from the tropics along the eastern slopes of the Andes, the precipitation patterns and associated divergent circulations and the energy budgets over the Amazon and the Andean highlands remain largely unvalidated and incompletely understood. Dynamical understanding of seasonal march of rainfall and its variability over Mexico and Central America are incomplete. The meteorological observation and analysis system for Latin America must also be improved to describe and understand the relationship between seasonal-to-decadal climate variability and the nature and frequency of significant weather events such as hurricanes and floods.

The Atlantic warm pool (located off the coast of NE Brazil extending northward into Caribbean region) and the Amazon basin are the regions where major atmospheric heat sources are located in the tropical Atlantic sector. Deep convective activities in these regions exhibit a strong seasonal cycle. Over the ocean the seasonal migration of the ITCZ co varies with the underlying warm water. The monsoon convection over the neighboring continent also contributes to the pronounced seasonal cycle. The strong seasonality in the atmospheric circulation produces a well-defined seasonal cycle in oceanic circulation in the region -- the North Brazil Current and North Equatorial Countercurrent both exhibit a strong seasonal variation. Superimposed on this seasonal cycle is a mode of climate variability in which the cross-equatorial SST gradient and the overlying atmospheric flow co varies on a decadal time scale. This mode of variability has a direct and significant influence on rainfall variability in the NE Brazil and Sub-Saharan West Africa.

Recent atmospheric GCM studies indicate that tropical Atlantic air-sea coupling takes place mainly in the Atlantic warm pool region. Simple coupled model studies show that it is in this region where delay is introduced in oceanic heat transport, setting a time scale for cross-equatorial SST gradient variation. Empirical and modeling studies also indicate that this is the region where the Pacific ENSO exerts the strongest influence on tropical Atlantic variability. More recent modeling studies suggest that feedback processes involving continental heating over the Amazon may also play a crucial role in cross-equatorial SST gradient variability. Although these preliminary studies point to the importance of land-atmosphere-ocean interactions over the Amazon basin and Atlantic warm pool, detailed mechanisms have not yet been fully explored.

The diagnostic studies of coupling between the Atlantic warm pool and the Amazonian region should include retrospective analyses of observational and reanalysis data. The focus of diagnostic studies will be on the investigation of atmospheric boundary layer processes, convective structure over the warm pool and the Amazon basin, dominant processes in surface heat flux, land and ocean processes that control the heat balance. Diagnostic studies of fully coupled model simulations are also needed to examine the models' ability in simulating tropical Atlantic mean state and climate variability and to determine potential causes of models' shortcomings. Furthermore, stand-alone and coupled modeling studies are envisioned to identify key feedback loops in the coupled land-atmosphere-ocean system and to formulate and test hypotheses.

Over North America there is a continental-scale monsoon-like circulation regime over the U.S. and Mexico that is associated with the summertime precipitation climate of the region. Some aspects of the seasonally varying climate over the southwest U.S., Mexico and Central America are not well described or understood. Large-scale patterns of drought and streamflow anomalies are empirically linked to potentially predictable Pacific SST anomalies on interannual to decadal time scales. Links between the summer monsoon in southwestern North America and summertime precipitation in the Great

Plains of the United States may have predictive value at the seasonal time scale. Potentially predictable anomalies of SST, soil moisture, snow cover and vegetation may play an important role in seasonal variability of the seasonal warm season precipitation patterns. In addition, there are large seasonal-to-interannual variations in the advective moisture supply and its magnitude relative to moisture supply from surface evaporation. The Great Plains low-level jet plays an important role in the summer precipitation and hydrology of the central U.S. while the Gulf of California low-level jet contributes to the summer precipitation and hydrology in the southwestern U.S. and Mexico.

Over South America, two features of immediate interest are: (1) the structure and role of the low level jet in the South American monsoon, and (2) land-ocean coupling mechanisms in the La Plata River Basin/South Atlantic Convergence zone region. As in the North American monsoon, potentially predictable anomalies of SST, soil moisture, snow cover and vegetation may play an important role in seasonal variability of warm season precipitation. There may be also be large seasonal-to-interannual variations in the advective moisture supply by the South American low level jet and the magnitude of this effect relative to moisture supply from surface evaporation. The low level jet and the mechanisms that control its structure are not well documented observationally. In addition, there is a need for better understanding of coupled ocean-atmosphere-land interactions in subtropical South America. Empirical studies have identified relationships between seasonal precipitation anomalies in subtropical South America and SST over the Pacific and Atlantic Oceans that may have predictive value for the region. Additional studies are needed to determine whether the tropical Atlantic SST variability is the dominant factor in the variability of the subtropical precipitation pattern, or whether regional processes in the SACZ are more important.

Empirical and diagnostic studies are needed to explore the hypothesis that the large-scale divergent circulation associated with seasonal precipitation patterns over South America is linked to the southeastern Pacific trade winds and the extensive decks of low-level boundary layer clouds. Such studies may now be feasible due to the development of improved in situ climate data sets, recent climate reanalyses, and increasingly useful satellite data sets, and may provide the basis for more extensive CLIVAR modeling and process studies. Theoretical results suggest that the eastern Pacific climate variability in both the tropical and subtropical regions is sensitive to the effects of the boundary layer clouds in the southeast Pacific. The variability of the major South American heat source regions in the Amazonian and Bolivian highland regions may therefore be linked to the eastern Pacific climate through its effect on the seasonal and longer time scale variability of stratocumulus decks and the underlying ocean. Andean orography and the effects of diurnal and synoptic-scale variability are likely to be important in the interpretation of the results.

Continuing efforts are needed to improve the understanding and simulation of coupling between the eastern Pacific cold-tongue/ITCZ complex and climate variability over Mexico, Central America and the Interamerican Seas. Warm season precipitation over Mexico and Central America exhibits a bimodal distribution with a midsummer drought that is associated with fluctuations in the intensity of the eastern Pacific ITCZ, and is linked to the Caribbean trade winds. Empirical and diagnostic studies are envisioned to explore the role of the cold-tongue/ITCZ complex (CTIC) and the warm pool off the west coast of southern Mexico and Central America in the evolution of the midsummer drought. New in situ and satellite data sets from EPIC (Eastern Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System) also provide an opportunity to understand and improve the simulation of the relationship between SST, surface wind stress, precipitation and cloudiness over the eastern Pacific CTIC.

Efforts are also needed to better understand the mechanisms that govern seasonal variations of floods, drought and storms. In the context of U.S. CLIVAR research, climate prediction is concerned not only with seasonal mean rainfall and temperature, but also with the frequency of occurrence of significant weather events such as hurricanes or floods over the course of a season or seasons. The empirical relationships between the statistical frequency and magnitudes of these events and climate variability on seasonal and longer time scales, and the degree to which these relationships can be simulated in coupled ocean-atmosphere-land models, must be established.